PATENT ABSTRACTS OF JAPAN

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(11)Publication number : 2001-007265

(43)Date of publication of application : 12.01.2001

(51)Int.Cl. H01L 23/473
B22D 19/00
B22D 19/14
H01L 23/373
H05K 7/20

(21)Application number : 11-174895

(22)Date of filing : 22.06.1999

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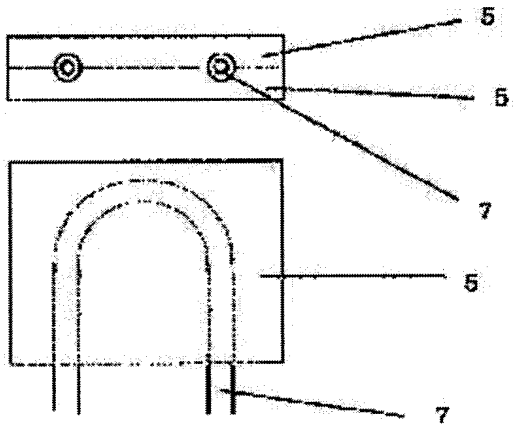
(54) SUBSTRATE WITH COOLING DEVICE AND PREPARATION THEREOF

(57)Abstract:

PROBLEM TO BE SOLVED: To improve cooling capacity by integrating a composite material substrate, consisting of ceramic with a low thermal coefficient of expansion and metal, or a carbon material and metal, and a cooling device with metal.

SOLUTION: Two substrates of a preform 5 made of a composite material are manufactured, and a semicircular groove is cut to each preform substrate. A stainless steel pipe 7, that is shaped to the groove in advance is pinched by the two preform substrates for tentative locking which is installed in a mold and aluminum molten metal, is poured for casting, subjected to cooling, then cutting machining is made to form parts, thus completely filling aluminum in the gap of a preform 5, filling the area between the stainless steel pipe 7 and the substrate with aluminum without gaps for integration. Therefore, the thermal coefficient of expansion of a substrate surface is 5×10-6/°C, which is close to that of silicon, alumina, and aluminum nitride to be jointed to the substrate surface. The substrate has a thermal conductivity of 200 W/m.K and can be used as a substrate.



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[Date of request for examination]

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rejection]

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[Date of extinction of right]

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(19)日本国特許庁（ＪＰ）　(12)公開特許公報（Ａ）　(11)特許出願公開番号
特開2001－7265
（P2001－7265A）
(43)公開日　平成13年１月12日(2001.1.12)

(51)Int.Cl.[7]	識別記号	ＦＩ		テーマコード（参考）
Ｈ０１Ｌ　23/473		Ｈ０１Ｌ　23/46	Ｚ	５Ｅ３２２
Ｂ２２Ｄ　19/00		Ｂ２２Ｄ　19/00	Ａ	５Ｆ０３６
			Ｅ	
19/14		19/14	Ａ	
			Ｂ	

審査請求　未請求　請求項の数５　ＯＬ　（全　４　頁）　最終頁に続く

(21)出願番号　特願平11－174895

(22)出願日　平成11年６月22日(1999.6.22)

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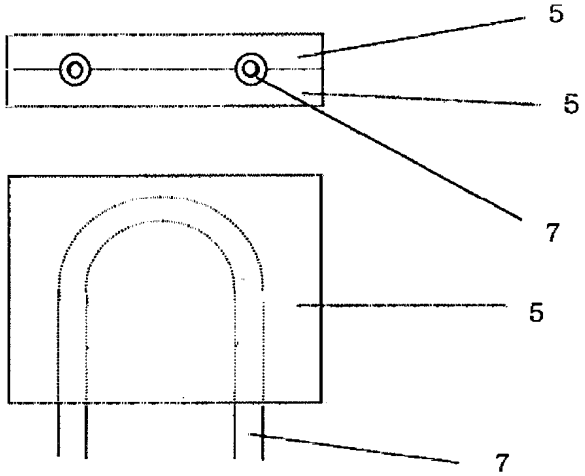
Ｆターム(参考)　5E322 AA01 AA07 AB11
5F036 AA01 BB08 BD01 BD11 BD13

(54)【発明の名称】　冷却装置付基板及びその製法

(57)【要約】
【課題】セラミックスと金属の複合材あるいは炭素と金属の複合材からなる電子回路用基板と液体あるいは気体を冷却媒体とする冷却装置を一体化して冷却効率を向上する。
【解決手段】セラミックスと金属の複合材あるいは炭素と金属の複合材からなる電子回路用基板と冷却装置を同時に鋳造し一体化する。あるいは、金属ロウ材、はんだ、金属箔等で基板と冷却装置を接続一体化する。



【特許請求の範囲】
【請求項１】電子基板の熱除去を目的とし、セラミックと金属あるいは炭素材と金属からなる複合材基板と液体を冷却媒体とする冷却装置が金属で一体化している冷却装置付基板。
【請求項２】電子基板の熱除去を目的とし、セラミックと金属あるいは炭素材と金属からなる複合材基板と気体を冷却媒体とする冷却装置が金属で一体化している冷却装置付基板。
【請求項３】電子基板の熱除去を目的とし、セラミックと金属あるいは炭素材と金属からなる２枚の複合材基板が液体を媒体とする冷却装置をはさみ一体化している冷却装置付基板。
【請求項４】請求項１、請求項２、請求項３のセラミックと金属あるいは炭素材と金属からなる複合材基板の熱膨張率が１０×１０$^{-6}$／℃以下、熱伝導率が１２０Ｗ／（ｍ・Ｋ）以上のいずれかである基板。
【請求項５】請求項１、請求項２、請求項３の複合材基板の金属が、アルミニウム、マグネシウム、銅、銀、あるいはそれらのひとつ以上を含む合金から選ばれる。
【発明の詳細な説明】
【０００１】
【発明の属する技術分野】本発明は、半導体素子あるいは電子機器の熱除去法に関して、基板及び液体を媒体とする冷却装置並びにその製造方法に関する。
【０００２】
【従来の技術】従来、電子回路から発生する熱を液体状の冷却媒体に伝熱する場合、回路を搭載する基板と冷却装置、例えばパイプ、平板状、角型の流路からなる装置は、個別に製造され、はんだ、ロウ材、樹脂製接着剤あるいは伝熱シートを挟んでねじ止めで接合されている。また、熱発生が多くなるにつれて、回路を搭載する基板に熱伝導率が高く、熱膨張率がアルミナのそれに近いセラミックスと金属あるいは炭素材と金属からなる複合材基板が使用されている。
【０００３】また、銅、アルミニウムを基板とするものには、パイプ等からなる冷却装置を基板にロウ材、はんだで接合し、金属基板と冷却装置が一体化されたものがある。
【０００４】
【発明が解決しようとする課題】金属基板を熱膨張率の低いセラミックと金属あるいは炭素材と金属からなる複合材基板にして信頼性を向上する。複合材基板と冷却装置を一体化することで、冷却能力をあげる。
【０００５】複合材基板とすることにより、基板の熱膨張率を搭載される半導体素子あるいはまた、アルミナ、窒化アルミニウム製の絶縁回路基板の熱膨張率に近づけ、界面における熱膨張率差から生じる熱応力を低減し、特に温度変化から生じる熱疲労による組織破壊によるそり、はがれを抑制する。これにより電子装置の信頼性を向上させることができる。
【０００６】低熱膨張率のセラミックと金属あるいは炭素材と金属からなる複合材基板の製造と冷却装置を熱伝導率の高い金属で一体化することにより、冷却能力を上げることが可能である。特に複合材基板製造する場合に冷却装置を一体で鋳造することにより、複合材基板と冷却装置を、金属の巣あるいは空隙なく密着することができ、冷却能力の向上効果は大きい。
【０００７】２つの基板の間に冷却装置を設置し、その両面に電子機器を搭載することで電子装置を小型化することができる。
【０００８】
【課題を解決するための手段】炭化珪素、アルミナ、窒化アルミニウム、窒化珪素の焼結体あるいは炭素の繊維状あるいは粉の焼結体からなるプリフォーム基板と冷却装置を金型に入れ、アルミニウムあるいは銅又は、それらの合金を溶融し高圧で鋳造する。この工程で、プリフォーム基板の空孔は金属で充填されセラミックあるいは炭素材と金属からなる複合材基板となり、同時に冷却装置と複合材基板が一体化する。または、別々に製造された複合材基板と冷却装置を金属、例えば、金属ロウ、はんだあるいは、金属箔で接合する。
【０００９】本発明において、用いられるアルミナ、窒化アルミニウムのプリフォーム基板材は、粉体、繊維状あるいはフェルト状の原料とガラス質の焼結材の混合物を焼結したもので、気孔率は５％以上５０％未満のものである。
【００１０】本発明において、用いられる炭素材のプリフォーム基板材は、粉体、繊維状あるいはフェルト状の原料と樹脂あるいはコールタールピッチ焼結材の混合物を焼結したもので、気孔率は５％以上５０％未満のものである。
【００１１】プリフォーム基板の気孔径は、サブミクロンから数百ミクロンに分布している。この気孔を溶融した金属で充填するためには、溶融金属の圧力をラム断面積あたり２００ｋｇ／cm^{2}以上１５００ｋｇ／cm^{2}とする必要がある。
【００１２】プリフォーム基板と冷却装置を空隙なく一体化するためには、溶融金属の圧力をラム断面積あたり２００ｋｇ／cm^{2}以上とする必要がある。
【００１３】
【発明の実施の形態】
【００１４】以下、発明の実施の形態を実施例に基づく図面を参照して説明する。プリフォーム基板と冷却装置であるパイプを仮設し一体化した部品を予熱後、金型にいれる。溶融金属を同金型に入れプレス機で加圧する。この条件を３０分間保ちその後金型から鋳造品を取り出す。同鋳造品から一体化した部品を研削加工する。その基本配置は図１で示される。
【００１５】以下、実施例により本発明をさらに説明す

るが、本発明の技術的範囲がこれに限定されるものではない。

実施例１

人造黒鉛材を切り出し、長さ１００㎜、幅１００㎜、厚さ１０㎜のプリフォーム基板を２枚製作する。　プリフォーム基板に直径１２㎜の半円状の溝を切る。２枚のプリフォーム基板でこの溝に合わせて予め整形した外形９．５㎜のステンレスパイプを挟み仮止めする。これを金型内におきアルミニュウム（ＪＩＳＡＣ４ＣＨ）溶湯を注ぎ圧力５００Kg/cm2で鋳造し、冷却後切削加工し、部品とする。（図２）

【００１６】実施例２

炭化珪素を高融点ガラスで焼成した成形体を切り出し、長さ１００㎜、幅１００㎜、厚さ１０㎜のプリフォーム基板に直径１２㎜の半円状の溝を切る。この溝に合わせて予め整形した外形９．５㎜のステンレスパイプを仮止めする。これを金型内におき溶融したアルミニウム（ＪＩＳＡＣ４ＣＨ）を注ぎ５００Kg/cm2の圧力で鋳造し、冷却後切削加工し、部品とする。（図３）

【００１７】実施例３

一方向に炭素繊維が配列している炭素複合材を繊維方向に直行して切断することで製造した基板から長さ５０ｍｍ、幅５０㎜、厚さ１０㎜のプリフォーム基板に長さ５０㎜、幅１㎜、深さ２㎜の溝を２㎜ピッチで２０個切る。この溝に長さ５０㎜、幅２０㎜、厚さ０．９㎜の人造黒鉛材から切り出した薄板を差込み、鋼材で製作した型に離型材を介して仮止めする。これを金型内におきアルミニュウム（ＪＩＳＡＣ４ＣＨ）溶湯を注ぎ圧力５００Kg/cm2で鋳造し、冷却後型から取り出し切削加工する。（図４）

【００１８】実施例１及び実施例２において、切断面を顕微鏡で観察したところ、アルミニウムがプリフォームの空隙を完全に充填していた。またステンレスパイプと基板間はアルミニウムで空隙なく充填され、一体化していた。

【００１９】

【発明の効果】本発明は、以下に記載する効果を生じる。

【００２０】基板面の熱膨張率が、実施例１の基板で５×10^{-6}／℃、実施例２で７×10^{-6}／℃、実施例３で１０×10^{-6}／℃で、基板面に接合されるシリコン、アルミナ、窒化アルミニウムの熱膨張率に近くなった。

【００２１】基板の熱伝導率が、実施例１の基板で２００Ｗ／ｍ・Ｋ、実施例２で１２０Ｗ／ｍ・Ｋ、実施例３で４００Ｗ／ｍ・Ｋあり、基板として使用できる。

【００２２】基板と冷却パイプあるいはフィンを接合するための熱伝導率の低いはんだ、ろう材、樹脂の接合層がなく、また界面に空隙がなく熱伝導が良好である。

【００２３】実施例１の冷却装置の両面を基板とし、両面に電子機器を搭載することで電子機器の占有体積を減少できる。

【図面の簡単な説明】

【図１】試作品の設定位置図である。

【図２】実施例１で試作した両面が基板となっている液冷用部品の平面及び立面図である。

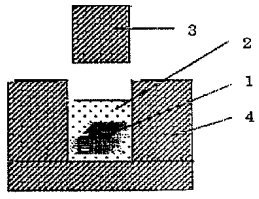
【図３】実施例２で試作した片面が基板となっている液冷用部品の平面及び立面図である。

【図４】実施例３で試作した片面が空冷用のフィンとなっている部品の平面及び立面図である。

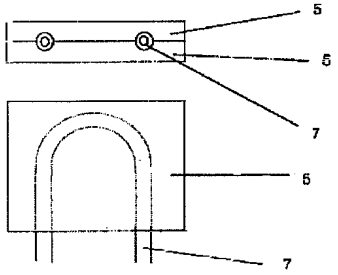
【符号の説明】

１　試作品
２　溶融した金属
３　プレス機のラム
４　金型
５　複合材プリフォーム
６　金属
７　パイプ
８　薄板（フィンとなる）
９　型

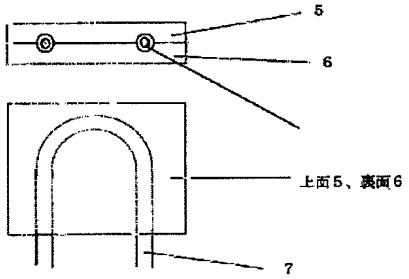
【図１】



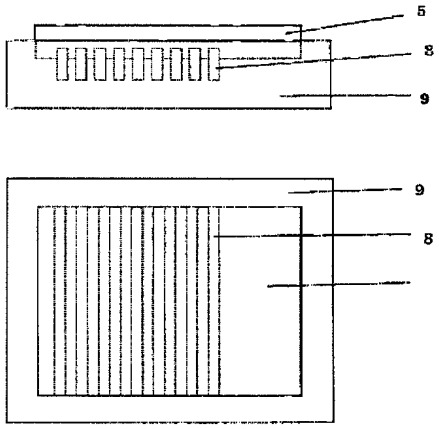
【図２】



【図３】



【図４】



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(51)Int.Cl.[7]	識別記号	ＦＩ		(参考)
Ｂ２２Ｄ　19/14		Ｂ２２Ｄ　19/14	Ｃ	
Ｈ０１Ｌ　23/373		Ｈ０５Ｋ　7/20	Ｍ	
Ｈ０５Ｋ　7/20		Ｈ０１Ｌ　23/36	Ｍ	

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CLAIMS

[Claim(s)]
[Claim 1] The substrate with a cooling system with which the cooling system used as a cooling medium is uniting with the metal the composite substrate which consists of a ceramic, a metal, or carbon material and a metal for the purpose of the heat removal of an electronic substrate, and the liquid.
[Claim 2] The substrate with a cooling system with which the cooling system used as a cooling medium is uniting with the metal the composite substrate which consists of a ceramic, a metal, or carbon material and a metal for the purpose of the heat removal of an electronic substrate, and the gas.
[Claim 3] The substrate with a cooling system which two composite substrates which consist of ceramics, metals, or carbon material and metals for the purpose of the heat removal of an electronic substrate are unifying on both sides of the cooling system through a liquid.
[Claim 4] The substrate whose thermal conductivity the coefficient of thermal expansion of the composite substrate which consists of a ceramic, a metal, or the carbon material and metal of claim 1, claim 2, and claim 3 is less than [10x10-6/degree C], and is either more than [120W / (m-K) more than].
[Claim 5] The metal of the composite substrate of claim 1, claim 2, and claim 3 is chosen from aluminum, magnesium, copper, silver, or the alloy containing those one or more.

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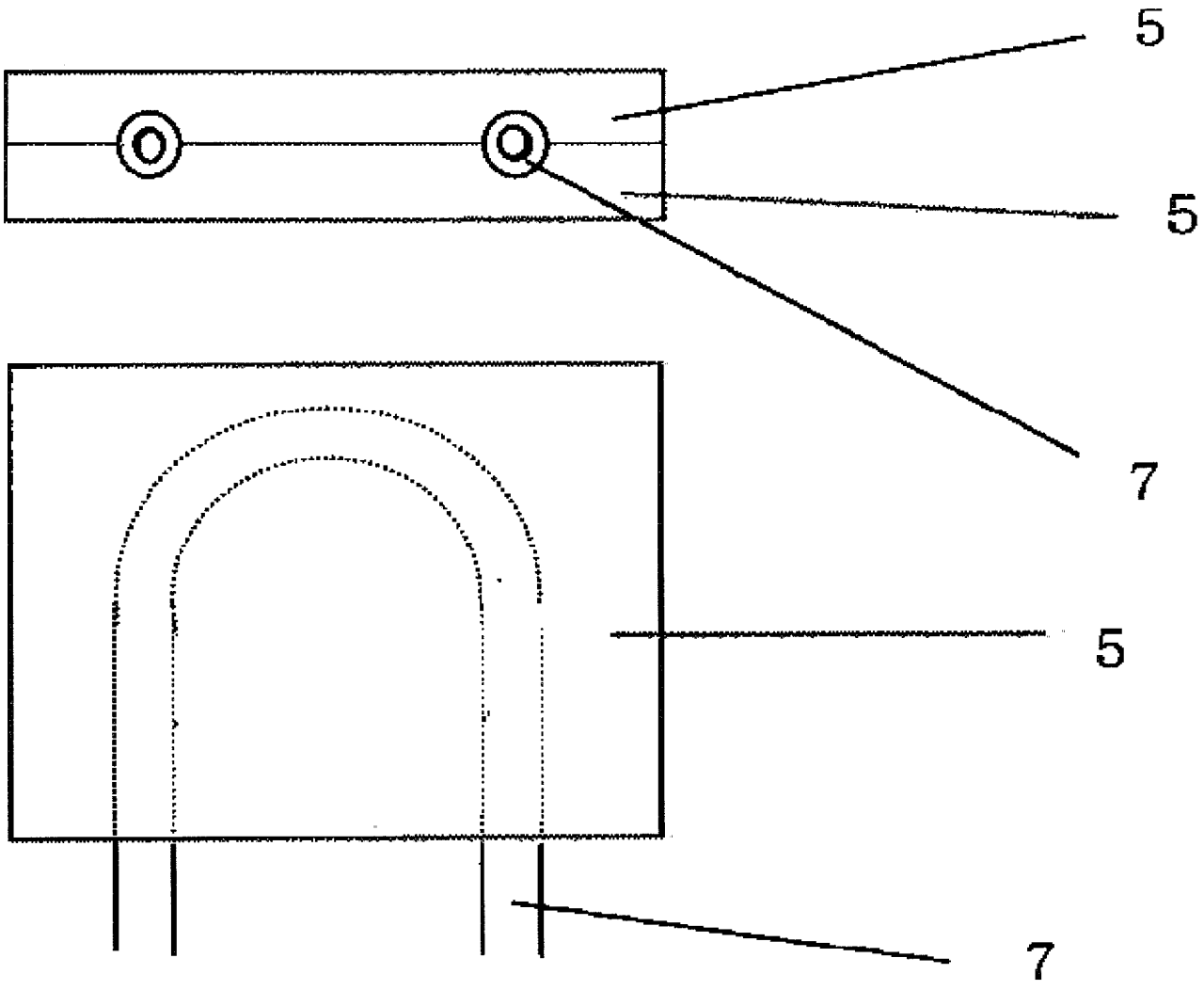
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DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Field of the Invention] This invention relates to the manufacture approach about a semiconductor device or the heat removal method of electronic equipment at the cooling-system list through a substrate and a liquid.
[0002]
[Description of the Prior Art] When carrying out heat transfer of the heat generated from an electronic circuitry to a liquid-like cooling medium conventionally, the substrate in which a circuit is carried, a cooling system, for example, a pipe, plate-like, and the equipment that consists of passage of a square shape are manufactured according to an individual, is ****ed on both sides of solder, low material, the adhesives made of resin, or a heat transfer sheet, and is joined by the stop. Moreover, thermal conductivity is high to the substrate in which a circuit is carried, and the composite substrate with which coefficient of thermal expansion consists of the ceramics near it, a metal, or the carbon material and metal of an alumina is used as heat release increases.
[0003] Moreover, the cooling system which consists of a pipe etc. is joined to a substrate with low material and solder, and some with which the metal substrate and the cooling system were united are one of those which use copper and aluminum as a substrate.
[0004]
[Problem(s) to be Solved by the Invention] A metal substrate is used as the composite substrate which consists of a low ceramic, a metal, or the carbon material and metal of coefficient of thermal expansion, and dependability is improved. Refrigeration capacity is raised with unifying a composite substrate and a cooling system.
[0005] By considering as a composite substrate, it brings close to the semiconductor device in which the coefficient of thermal expansion of a substrate is carried, or the coefficient of thermal expansion of the insulating circuit board of the product made from an alumina and alumimium nitride again, and the thermal stress produced from the coefficient-of-thermal-expansion difference in an interface is reduced, it is based on the organization destruction by the thermal fatigue produced [especially] from a temperature change, and curves, and peeling is controlled. Thereby, the dependability of an electronic instrument can be raised.
[0006] By unifying the manufacture and the cooling system of a composite substrate which consist of a ceramic, a metal, or the carbon material and metal of a low-fever expansion coefficient with a metal with high thermal conductivity, it is possible to improve refrigeration capacity. When carrying out especially composite substrate manufacture, by casting a cooling system in one, a composite substrate and a cooling system can be stuck without a metaled blow hole or an opening, and the improvement effectiveness of refrigeration capacity is large.
[0007] A cooling system can be installed between two substrates and an electronic instrument can be miniaturized by carrying electronic equipment in the both sides.
[0008]
[Means for Solving the Problem] The preforming substrate and cooling system which consist of fibrous [of the sintering object of silicon carbide, an alumina, alumimium nitride, and silicon nitride or carbon] or a sintering object of powder are put into metal mold, aluminum, copper, or those alloys are fused, and it casts in high pressure. At this process, the hole of a preforming substrate serves as a composite substrate which is filled up with a metal and consists of a ceramic or carbon material, and a metal, and a cooling system and a composite substrate unite it with coincidence. Or the composite substrate and cooling system which were manufactured separately are joined by the metal, for example, a metal low, solder, or the metallic foil.
[0009] In this invention, the preforming substrate material of the alumina used and alumimium nitride is what sintered the raw material of the shape of fine particles, fibrous, or felt, and the mixture of the sintering material of

glassiness, and porosity is 5% or more less than 50% of thing.
[0010] In this invention, the preforming substrate material of the carbon material used is what sintered the mixture of the raw material of the shape of fine particles, fibrous, or felt, resin, or coal-tar pitch sintering material, and porosity is 5% or more less than 50% of thing.
[0011] The pore diameter of a preforming substrate is distributed over hundreds of microns from submicron one. In order to fill up with the metal which fused this pore, it is necessary to make the pressure of molten metal into 200kg/cm2 or more per ram cross section 1500kg/cm2.
[0012] In order to unify a preforming substrate and a cooling system without an opening, it is necessary to make the pressure of molten metal into 200kg/cm2 or more per ram cross section.
[0013]
[Embodiment of the Invention]
[0014] Hereafter, the gestalt of implementation of invention is explained with reference to the drawing based on an example. The components which built temporarily the pipe which are a preforming substrate and a cooling system, and were unified are put into metal mold after a preheating. Molten metal is put into this metal mold, and it pressurizes with a press machine. This condition is maintained for 30 minutes and a cast is picked out from metal mold after that. The grinding process of the components unified from this cast is carried out. The basic arrangement is shown by drawing 1 .
[0015] Hereafter, although an example explains this invention further, the technical range of this invention is not limited to this.
Example 1 artificial-graphite material is started and two preforming substrates with die length of 100mm, a width of face [of 100mm], and a thickness of 10mm are manufactured. The slot of the shape of a semicircle with a diameter of 12mm is cut to a preforming substrate. It carries out [tacking] on both sides of the stainless steel pipe of 9.5mm of appearances orthopedically operated beforehand according to this slot with two preforming substrates. An aluminum (JISAC4CH) molten metal is poured out in the inside of metal mold, and this is cast in pressure 500 kg/cm2, and carries out after [cooling] cutting, and it considers as components. (Drawing 2)
[0016] The Plastic solid which calcinated example 2 silicon carbide with high-melting glass is cut down, and the slot of the shape of a semicircle with a diameter of 12mm is cut to a preforming substrate with die length of 100mm, a width of face [of 100mm], and a thickness of 10mm. It carries out [tacking] of the stainless steel pipe of 9.5mm of appearances orthopedically operated beforehand according to this slot. The aluminum (JISAC4CH) which and fused this is poured out, after [cooling] cutting is cast and carried out by the pressure of 500 kg/cm2, and it considers as components. [aluminum] [of metal mold] (Drawing 3)
[0017] A slot with die length of 50mm, a width of face [of 1mm], and a depth of 2mm is cut with 20 2mm pitches to a preforming substrate with die length of 50mm, a width of face [of 50mm], and a thickness of 10mm from the substrate manufactured by going to a grain direction direct and cutting the graphite composite which the carbon fiber has arranged to example 3 one direction. The sheet metal cut down from artificial-graphite material with die length of 50mm, a width of face [of 20mm], and a thickness of 0.9mm is fitted over this slot, and it carries out [tacking] to the mold manufactured with steel materials through a release agent. An aluminum (JISAC4CH) molten metal is poured out in the inside of metal mold, and it casts in pressure 500 kg/cm2, and this is taken out from the mold after cooling and carries out cutting. (Drawing 4)
[0018] In the example 1 and the example 2, when the cutting plane was observed under the microscope, aluminum was completely filled up with the opening of preforming. Moreover, it filled up with aluminum without the opening between the stainless steel pipe and the substrate, and it was unified.
[0019]
[Effect of the Invention] This invention produces the effectiveness indicated below.
[0020] The coefficient of thermal expansion of a substrate side became close to the coefficient of thermal expansion of the silicon to which it is joined by 7x10-6/degree C in 5x10-6/degree C and the example 2, and it is joined by the substrate side at 10x10-6/degree C by the example 3 with the substrate of an example 1, an alumina, and alumimium nitride.
[0021] The thermal conductivity of a substrate can use it by 200 W/m-K with the substrate of an example 1, and can use it as those with 400 W/m-K, and a substrate in 120 W/m-K and the example 3 by the example 2.
[0022] There is no junctional zone of solder with the low thermal conductivity for joining a substrate, a cooling pipe, or a fin, wax material, and resin, and there is no opening in an interface, and heat conduction is good.
[0023] Both sides of the cooling system of an example 1 are used as a substrate, and the occupied volume of

electronic equipment can be decreased by carrying electronic equipment in both sides.

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DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]
[Drawing 1] It is the setting location Fig. of a prototype.
[Drawing 2] It is the flat surface and elevation of the components for liquid cooling where both sides made as an experiment in the example 1 serve as a substrate.
[Drawing 3] One side made as an experiment in the example 2 is the flat surface and elevation of the components for liquid cooling used as a substrate.
[Drawing 4] One side made as an experiment in the example 3 is the flat surface and elevation of components used as the fin for air cooling.
[Description of Notations]
1 Prototype
2 Fused Metal
3 Ram of Press Machine
4 Metal Mold
5 Composite Preforming
6 Metal
7 Pipe
8 Sheet Metal (it Becomes Fin)
9 Mold

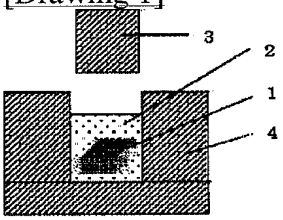
[Translation done.]

* NOTICES *

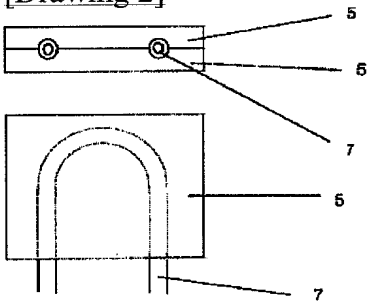
1.This document has been translated by computer. So the translation may not reflect the original precisely.
2.**** shows the word which can not be translated.
3.In the drawings, any words are not translated.

DRAWINGS

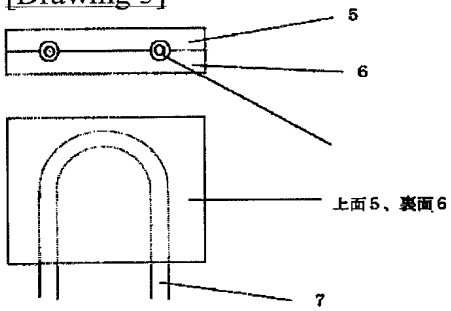
[Drawing 1]



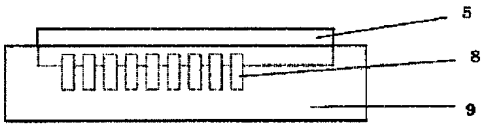
[Drawing 2]

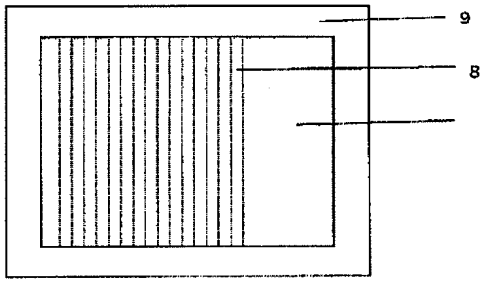


[Drawing 3]



[Drawing 4]





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